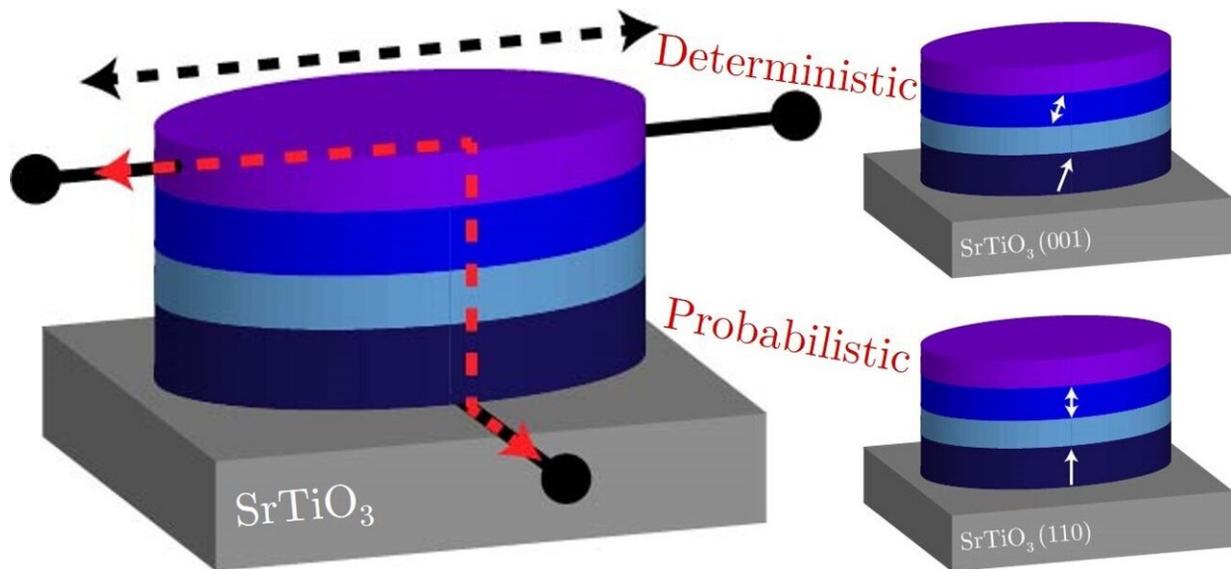


New material could create 'neurons' and 'synapses' for new computers

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Schematic of the proposed device structure for neuromorphic spintronic memristors. The write path is between the terminals through the top layer (black dotted line), the read path goes through the device stack (red dotted line). The right side of the figure indicates how the choice of substrate dictates whether the device will show deterministic or probabilistic behaviour. Credit: Banerjee group, University of Groningen

Classic computers use binary values (0/1) to perform. By contrast, our brain cells can use more values to operate, making them more energy-efficient than computers. This is why scientists are interested in neuromorphic (brain-like) computing. Physicists from the University of

Groningen (the Netherlands) have used a complex oxide to create elements comparable to the neurons and synapses in the brain using spins, a magnetic property of electrons. Their results were published on 18 May in the journal *Frontiers in Nanotechnology*.

Although computers can do straightforward calculations much faster than humans, our brains outperform silicon machines in tasks like object recognition. Furthermore, our brain uses less energy than computers. Part of this can be explained by the way our brain operates: whereas a [computer](#) uses a binary system (with values 0 or 1), [brain cells](#) can provide more analogue signals with a range of values.

Thin films

The operation of our brains can be simulated in computers, but the basic architecture still relies on a binary system. That is why scientist look for ways to expand this, creating hardware that is more brain-like, but will also interface with normal computers. "One idea is to create [magnetic bits](#) that can have intermediate states," says Tamalika Banerjee, Professor of Spintronics of Functional Materials at the Zernike Institute for Advanced Materials, University of Groningen. She works on spintronics, which uses a magnetic property of electrons called 'spin' to transport, manipulate and store information.

In this study, her Ph.D. student Anouk Goossens, first author of the paper, created [thin films](#) of a ferromagnetic metal (strontium-ruthenate oxide, SRO) grown on a substrate of strontium titanate oxide. The resulting thin film contained magnetic domains that were perpendicular to the plane of the film. "These can be switched more efficiently than in-plane magnetic domains," explains Goossens. By adapting the growth conditions, it is possible to control the crystal orientation in the SRO. Previously, out-of-plane magnetic domains have been made using other techniques, but these typically require complex layer structures.

Magnetic anisotropy

The magnetic domains can be switched using a current through a platinum electrode on top of the SRO. Goossens: "When the magnetic domains are oriented perfectly perpendicular to the film, this switching is deterministic: the entire [domain](#) will switch." However, when the [magnetic domains](#) are slightly tilted, the response is probabilistic: not all the domains are the same, and intermediate values occur when only part of the crystals in the domain have switched.

By choosing variants of the substrate on which the SRO is grown, the scientists can control its magnetic anisotropy. This allows them to produce two different spintronic devices. "This magnetic anisotropy is exactly what we wanted," says Goossens. "Probabilistic switching compares to how neurons function, while the deterministic switching is more like a synapse."

The scientists expect that in the future, [brain](#)-like computer hardware can be created by combining these different domains in a spintronic device that can be connected to standard silicon-based circuits. Furthermore, probabilistic switching would also allow for stochastic computing, a promising technology which represents continuous values by streams of random bits. Banerjee: "We have found a way to control intermediate states, not just for memory but also for computing."

More information: A. S. Goossens et al, Anisotropy and Current Control of Magnetization in SrRuO₃/SrTiO₃ Heterostructures for Spin-Memristors, *Frontiers in Nanotechnology* (2021). [DOI: 10.3389/fnano.2021.680468](https://doi.org/10.3389/fnano.2021.680468)

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